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PRESERVATION
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Reducing Visible and Ultraviolet Light Damage to Interior Wood Finishes

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One of the major sources of damage to finishes of historic millwork and furniture is light—especially sunlight. Sunlight can cause finishes to crack or flake and paints and stains to fade or disappear altogether. Even the cellular structure of the wood can be damaged, especially once the finish has broken down. With historic wood stains, the result can be a change in coloration—or worse, its complete loss. Even after wood had been refinished in the course of restoration, continued, unprotected exposure to sunlight may neccessitate additional conservation work.

As early as the 19th century, people were aware of the destructive nature of sunlight to interior furnishings. Curtains, Venetian blinds, and interior and exterior shutters were often used not only to keep rooms cool but to lessen color fading on the interiors of many buildings. With the advent of mechanical air-conditioning, the reliance on these traditional heat and light reducing devices has lessened, exposing historic interiors to increased risks of damage.

Museums with particularly sensitive materials, such as paintings and fabric, have addressed the problem in a variety of ways. One approach over the past 20 years has been the use of ultraviolet (UV) light filters in windows. These filters are effective in largely blocking one type of harmful rays—those of ultraviolet radiation. A 10-year fade test of wood stains by the National Park Service, however, suggest that *visible* light passing through windows protected with UV filters can cause significant damage to certain types of stains. This Tech Note covers the 10-year fade test and also

Appropriate steps should be taken to protect light-sensitive historic furnishings from damage caused by both ultraviolet light and visible sunlight

Wood Stain Durability Test
10 year test results

Figure 1. The 10-year test results of the National Park Service's Wood Stain Durability Test are shown. The upper half of the test board was exposed in a window to north light. The bottom was covered during the test period. Comparison of the corresponding exposed and unexposed areas reveals the extreme susceptibility of certain commonly used wood stains to damage by light. Photo: Mike Wiltshire, National Park Service.

discusses steps that can be taken to protect sensitive furnishings, even where UV window filters exist.

Problem

Radiated energy from the sun travels in different wavelengths, including ultraviolet light and visible light. Many museums have taken measures only to reduce the damage caused by ultraviolet light. While information is readily available on the effect of ultraviolet light on historic interiors, the photochemical damage to historic objects caused by visible light is less well known. In 1978, the Division of Conservation at the National Park Service's Harpers Ferry Center began a long-term test of the durability of different types of stains popularly used in furniture restoration work when exposed to ultraviolet and visible light.

Test Variables

To determine their durability, three stains were applied to clear white pine and then exposed to natural light over a 10-year period (*see figure 1*). Each stain was tested under three conditions:

Condition 1—One coat of each stain was applied and left exposed to natural light

Condition 2—One coat of each stain was applied and then protected by UF-3 Plexiglas to filter out ultraviolet light, leaving the stain exposed to visible light

Condition 3—One coat of each stain was applied followed by 2 coats of orange shellac (shellac being a traditional finish found on period furniture)

The stains tested consisted of two aniline dyes and one oil color mix. (Aniline dyes have been used since the 1850s because of their reasonable cost and ease of application.) The two aniline dyes used in the study were walnut colors, each from different manufacturers. As directed, one of the aniline dyes was mixed in warm water and the other in Solex-denatured alcohol. Equal concentrations of the aniline dyes were used in the two stains. The third stain tested consisted of two oil colors (burnt umber and burnt sienna) combined to create a mahogany walnut color and mixed in turpentine. From the outset, it was recognized that certain colors tend to be more stable than others; however, for the purpose of this test stability was not a selection factor. These three stains were selected because they were in common use at that time in the National Park Service's Conservation Laboratory for wood restoration on historic furnishings.

Procedure

A uniform coat was applied to each test block. One half of the surface of each wood test block was then covered with a wood panel to prevent light from hitting the stained surface. The covered section thus served as a control for comparison later on. The blocks of wood were placed on the inside of a window ledge that had northern exposure, meaning it received only indirect sunlight most of the year. Although the amount of natural light on the test block varied considerably throughout the day and from season to season, on a clear summer day it measured 1,400 foot-candles, as measured by a luxmeter.

Test Results

The two aniline dyes proved to be extremely light sensitive with noticeable fading even on a year-to-year basis. After 10 years, the aniline dye in both the water stain and the alcohol stain had faded so completely that the natural color of the wood predominated. Similar results occurred with the aniline dye coated with two coats of orange shellac.

The UF-3 Plexiglas filter had only negligible effect on the durability of the aniline dyes. The dyes in this case had nearly completely faded out as well. Tests were run using a Crawford UV monitor to determine whether the UF-3 Plexiglas was still performing at the same level as when first used. Readings taken on a clear summer day through the glass panes of the window indicated that approximately 450 microwatts per lumen were landing on the wood blocks. With the UF-3, 1/8″ Plexiglas, most of the ultraviolet rays coming through the window were being filtered out, as the reading of about 50 microwatts indicated. Also of interest in regards to the long-term effectiveness of such filters, both the 10-year old UF-3 Plexiglas used on the wood test blocks and new UF-3 Plexiglas registered the same ultraviolet reading.

The UF-3 Plexiglas and orange shellac seemingly offered insufficient protection against the harmful natural light during the 10-year test period. In stark contrast with the two aniline dyes, the oil stain was only minimally affected by the light. (This is not to imply, however, that over a much longer period noticeable differences might not occur with the oil stain.)

Although further testing would be needed to establish broader findings regarding the durability of stains when exposed to natural light, the 10-year test supports the following conclusions:

1. Natural light is damaging to certain types of wood finishes, even in cases of only indirect light exposure.
2. Although only a few aniline dyes were tested, the results strongly indicate that they are extremely light sensitive (*see figure 2*).
3. Certain oil colors (earthen pigments ground in oil) appear to produce a stable stain that resists fading.
4. UF-3 Plexiglas may shield out most of the ultraviolet light, yet visible light is left largely unfiltered and can be extremely damaging to light-sensitive objects and architectural woodwork.

Figure 2. A veneer repair patch, located on the front of the third drawer, has faded from light. This extreme fading is typical of areas where aniline stains have been applied. Photo: Mike Wiltshire, National Park Service.

Recommendations for Controlling Light

This study reveals that certain wood finishes and historic materials may be damaged by visible light as well as by ultraviolet radiation. As the study demonstrates, oil stains hold up better than some other finishes traditionally used on historic material, but none is immune to the destructive effects of light. It is imperative, therefore, to control light—all forms of it—as much as possible.

Ultraviolet Radiation — The destructive nature of ultraviolet light can be controlled to a large extent through the use of special filters. With many collections housed in historic buildings, it is fortunate that UV filters have only a minor effect on light which is seen and thus alter little of the coloration and reflective qualities of the window glass.

There are different options for installing ultraviolet filters. A common technique is the application of filtering films to the existing glass. This approach has been used for many years, and indications are that such filters can have a service life of 10 or more years, depending upon the materials and conditions involved. Most of the problems with recent film applications have occurred where the film has not been correctly installed, resulting in "bubbling" or other forms of adhesion failure. Experienced personnel must be used for installations. Removal of the film is very time-consuming and costly, since experienced people must be used to avoid scratching to the glass and gouging to the wood. Once installed, special care must be taken in the routine cleaning of the glass.

When investigating the options for controlling ultraviolet light, particularly when dealing with historic window sash and old glass, two important factors should be considered. When in the future the film requires replacement, there is the distinct possibility of damage to the historic glass and even the sash. And second, highly trained personnel must be employed in the preparations, application and future removal of the film, whether or not historic sash and glass is involved.

There are alternatives to the applications of filtering films. One is the addition of specially treated glass or plastic glazing panels, preferably to the room side, which can also serve as a storm panel, help lower dirt infiltration and reduce some visible sunlight. With this approach, a careful assessment would need to be made beforehand of the following: (1) the visual impact on the historic character of the building; (2) the best way to install the panel with minimal damage to the historic woodwork; and (3) the potential for moisture entrapment between the sash and panel. Installation of a test panel over the full seasonal cycle is recommended.

Even in rooms with no windows, there can be ultraviolet light from artificial sources, particularly fluorescent lights. Filtering sleeves can be installed over fluorescent tubes and lights are available with a built-in filter. Try to lower ultraviolet light levels to no more than 75 microwatts per lumen (*see figure 3*).

Visible Light — Besides the damage caused by ultraviolet light, this study suggests that visible light through windows can damage certain historic furnishings as well (*see figure 3*). With non-historic buildings, the use of specially tinted window film or glass effectively reduces light infiltration and therefore is often recommended as a way to help protect the historic furnishings.

When dealing with historic buildings, a number of additional factors must be considered in any plan to reduce light damage to historic materials. The use of visible light filters at windows in historic buildings can change the historic character of both individual windows and the overall building. Specially treated glass, films, and acrylic or polycarbonate sheets for control of visible light all have a distinct color because of the limited ways that visible light can be filtered. Green, gray and bronze are the most common colors of the various filters. There are many factors which help determine the visual impact of visible light filters on the historic appearance of the buildings, such as the color of the building, the depth of the window reveal, the artificial lighting within the building, the color of window blinds or draperies, and the visibility of the windows. In some cases, the use of a light non-reflective gray tint on secondary elevations may be acceptable, although not acceptable on the primary facades.

National Park Service Guidelines for Preservation and Protection of Museum Objects

Light (visible): The maximum acceptable illuminance level for light-sensitive materials is as follows:

50 lux (5 footcandles) for especially light-sensitive materials, e.g., dyed and treated organic material, textiles, watercolors, tapestries, prints and drawings, manuscripts, leather, wallpapers, natural history specimens including botanical specimens, fur and feathers.

200 lux (20 footcandles) for undyed and untreated organic materials, oil and tempera painting, and finished wooden surfaces.

Generally, other materials are less light-sensitive and may be exposed to higher levels up to a maximum of 300 lux. However, when these materials are exhibited with light-sensitive materials, light levels must be controlled at the levels acceptable for the most sensitive materials.

Except for short durations required for access or housekeeping, no light is acceptable for museum objects in storage.

Light (UV radiation): All forms of lighting (e.g., daylight, fluorescent lamps, tungsten [incandescent] and tungsten-halogen lamps) used in museums emit varying levels of UV radiation. Monitor all light sources of UV radiation and record levels. If the UV radiation level exceeds 75 microwatts/lumen, it is mandatory to control it by installing filtering material (e.g., plastic solar control film for windows, UV filtering film or sheet for windows or picture frames, and filter sleeves for fluorescent tubes) between the light source and museum objects. Periodically monitor UV radiation to ensure that filtering material is effective.

Figure 3. National Park Service "Guidelines for Preservation and Protection of Museum Objects" from visible and ultraviolet light.

As with the installation of films that filter only ultraviolet light, films that filter both ultraviolet light and visible light can have potential long-term damaging effects on the historic glass and even the sash when it has to be removed in the future. Unlike ultraviolet light filters, however, films that filter visible light may pose an additional hazard to the historic glass: these films cause the glass to absorb additional radiant heat from the sun, causing higher levels of expansion and contraction in the glass. This action can lead to the cracking of some historic glass, particularly where old hard glazing compound exists and with typical old glass that had more edge imperfections than found today. Obviously if the historic glass or sash has been replaced, any potential physical damage is of much less concern.

The best way to assess the visual impact of this type of filter is to install a field mock-up and observe it through seasonal changes. A light non-reflective gray-color film or glazing panel probably will have the least visible impact, although in many cases it still may be inappropriate for historic buildings.

A number of other steps can be taken with both historic and non-historic buildings and furnishings to control visible and ultraviolet light (*see figures 4 and 5*). Where the application of filtering films or specially treated glass is determined not in keeping with the historic character of a building, the following treatments are particularly important to consider:

1. Install window roller shades and use them at times of direct sunlight penetration and whenever a room is not in use, including at closing time.
2. Utilize existing shutters and Venetian blinds to control light into a room throughout the day.
3. Close draperies and curtains during times of direct sunlight and whenever a room is not in use. Where historic draperies exist, have reproductions made and use them in place of the historic draperies or curtains.
4. Locate particularly light-sensitive furnishings away from direct window light. With some historic museum settings, this may mean that a particular furnishing cannot be placed in its exact

Figure 4. A number of steps can be taken to control or reduce the damage to historic furnishings caused by light entering through windows. In this house museum, a reproduction table cloth is appropriate for use in protecting the mid-nineteenth century dining room table. The chair would be better protected by moving it away from the window. The dark window roller shade should be drawn in this house museum during periods of direct sunlight and when the building is closed to the public. Photo: Mike Wiltshire, National Park Service.

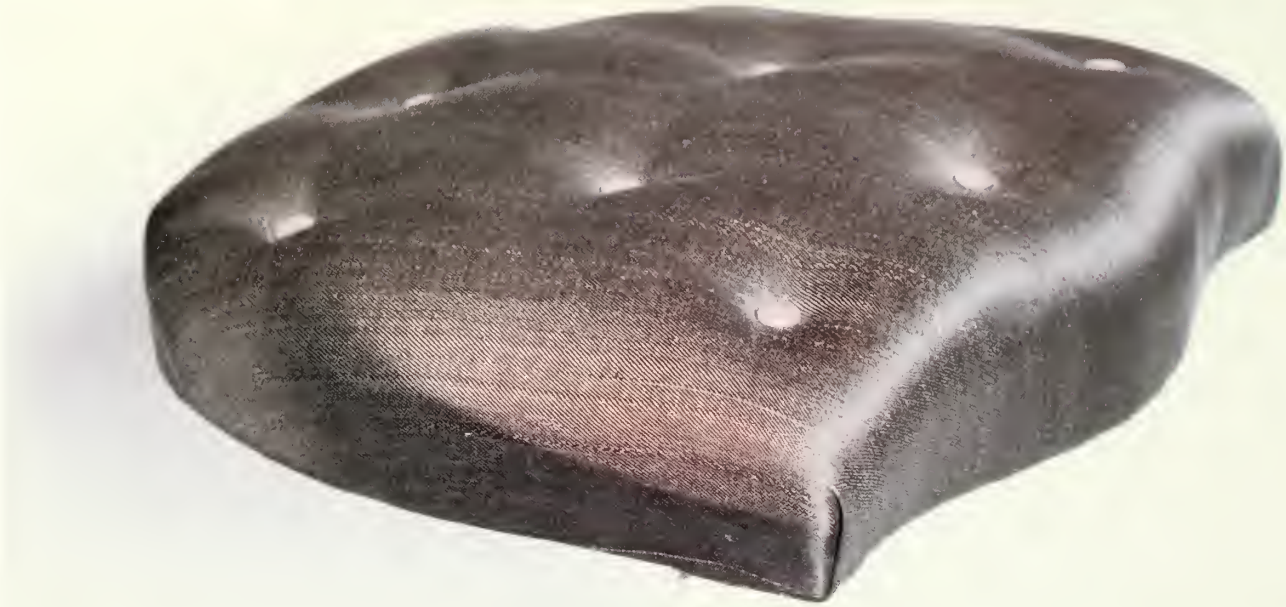

Figure 5. The chair seat, covered with reproduction black haircloth, similar to the one in figure 4, has faded in just eleven years due to exposure to unfiltered natural light. The unfaded (dark) area on the side of the seat was protected from the light by the seat rail of the chair. Photo: Mike Wiltshire, National Park Service.

Figure 6. This small table and wooden box should not have been located beneath the window. Light has faded the finish of the table top except in the center, where the box rested and shielded the finish. The finish on the top and back of the box is nearly completely lost. Photo: Mike Wiltshire, National Park Service.

historic location (*see figure 6*).

5. Cover historic furnishings with muslin or other material when a room is not in regular use. Store light-sensitive furnishings in darkened facilities.
6. Where awnings are historically appropriate, utilize them to reduce sunlight from entering the interior.
7. Carefully study the existing landscape and, when appropriate, plant additional trees and vegetation that may help reduce sunlight.
8. In repairing and restoring historic woodwork, use stains and finishes that exhibit high color stability and that are compatible with the historic stain and finish. This test suggests avoiding aniline dyes.
9. Take light readings both for ultraviolet light (microwatts per lumen) and visible light (lux or foot candle) on a seasonal basis to make sure that the levels are within the recommended range for the room or building.

Evaluation and Conclusion

Although the loss of color in wood finishes due to light depends in part on the pigment and medium involved, the impact of natural light (both visible and ultraviolet) on historic furnishings today is recognized as a major concern to the preservation of light-sensitive material. Even with the limited scope of this stain test, the results along with other accumulated evidence in the museum field reinforce the need to control and reduce sunlight exposure to historic furnishings and woodwork susceptible to damage. Before using stains and finishes in restoration work, product literature regarding light sensitivity and durability should be reviewed, and furnishings and woodwork already restored should be monitored in the absence of definitive information from manufacturers. The use of draperies, interior shutters and other traditional features as well as modern solar controlling devices such as automatic blinds should be considered, and, where appropriate, utilized on a regular basis to protect historic furnishings.

Additional Reading:

"A Comparison of Selected UV Filtering Material for the Reduction of Fading," by Patricia Cox Crews, *Journal of the American Institute for Conservation*, Vol. 28, No. 2, Fall 1989.

Conserve-O-Gram Series, National Park Service, Washington, D.C.

The Museum Environment (Second Edition), by Garry Thomson, Butterworth, Boston, 1986.

"Protecting Interior Furnishings and Finishes from Sunlight Damage," by James A. Moisson, *Window Workbook for Historic Buildings*, Historic Preservation Education Foundation, Washington, D.C. 1986.

"Textile Conservation for Period Room Settings in Museums and Historic Houses," by Margaret Fikioris, *Preservation of Paper and Textiles of Historic and Artistic Value II*, American Chemical Society, Washington, D.C. 1981.

PROJECT DATA

Test Facility:
Division of Conservation
Harpers Ferry Center
National Park Service
Harpers Ferry, West Virginia

Project Date:
1978 to 1988

Stains Tested:

(1) #720 Walnut Aniline Dye
Golden Star Refinishing Product
mixed in hot water
(2) #482 Walnut Aniline Dye
Cambells Dry Aniline Stain
mixed in Solex denatured alcohol
(3) Umber and Burnt Sienna Oil Colors
Behlens Oil Colors
mixed in turpentine

Equipment and Materials:

UF-3 1/8" Plexiglas
Crawford UV monitor
Gossen Panlux luxmeter
White Pine Wood

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PRESERVATION TECH NOTES are designed to provide practical information on practices and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures and standards. This Tech Note was prepared pursuant to the National Historic Preservation Amendments of 1980 which direct the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

Comments on the usefulness of this information are welcomed and should be addressed to PRESERVATION TECH NOTES, Preservation Assistance Division-424, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

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